Geo-spatial technique for vegetation carbon pool assessment in western Ghat of India

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Abstract

Remote Sensing has become a valuable source of information over past three decades for forest mapping and monitoring activities. New development in remote sensing technology have indicate that, if these method are judiciously combine with ground- based studies, it is possible to carry out detailed forest inventory and monitoring of natural vegetation cover. The information content of available in multispectral data has become a necessity for integrated resource inventory in modern forestry practices. This study demonstrates the use of high resolution IRS P-6 LISS-III data for phytomass assessment in Gir Reserve Forest, Junagar (Gujarat). The study also shows good scope of high resolution data for Biomass assessment which will be responsible for Carbon stock analysis. The primary goal of this study is to identify the status of forest vegetation and land uses for mitigation of CO₂ through conservation and management of terrestrial forest in India. Remote sensing and Geographical Information System (GIS) were taken as tools and techniques for identification, mapping, monitoring and evaluation of all forest.

Key Words: Remote Sensing, Biomass, Carbon secquiciation, Land cover Mapping.

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Global carbon is held in a variety of different stock. Natural stocks include oceans fissile fuel deposit, the terrestrial system and the atmosphere. In the terrestrial system carbon is sequestered in rocks and sediments in swamps, wetland and forests, grassland and agriculture. Depending upon the use, any or all of these can act as sink or source of carbon. Whether India is a net sink or source of carbon is poorly understood. Systemic studies therefore are requiring assessing the pools and fluxes of carbon to arrive at country level carbon budget.

A sink is defined as a process or an activity that remove greenhouse gasses from the atmosphere. Carbon secquiciation is the extraction of the atmosphere CO₂ and its storage in terrestrial ecosystem for a very long period of time many 1000's of years (Chhabra *et al.*, 2002). Forest offers some potential to manage as a sink that is primitive net carbon secquiciation.

This study describes an effort to estimate carbon stock using remote sensing for Gir reserve forest of Gujarat in India. Measuring carbon stock particularly based on vegetation (forest) cover derived from remote sensing. This vegetation cover is

then converted to carbon by multiplying with biomass-carbon conversion factors. The vegetation cover was accomplished using regression tree method.

Study Area

The aim of the study was to establish a regional model for a quick assessment of biomass in a scale that is usable for planning purposes. Since satellite data have been available, the direct quantification of biomass and other vegetation parameters have become a focus of research for this object.

- Estimation of Area-Level Forest Phytomass C.
- Vegetation Carbon Assessment pool.
- To generate the vegetation cover dynamic and to prepare a land use and land cover map.

The Gir National Park and Wildlife Sanctuary is located about 65 kms to the south-east of Junagadh city of the Junagar district in the Kathiawar peninsula of Gujarat state, India. Established in 1965, it has a total area of 1412 km squares in which 258 km square area comes under "fully protected area" and 1153 km square area is for the Sanctuary. It is basically a hilly tract of dry deciduous forests, acacia scrub, evergreen and semi-evergreen flora and

grasslands, fed by rivers and streams. But it is mainly famous of the only remaining place in the world, where one is likely to see the pure Asiatic lions (*Panthera Leo persica*). At present there are nearly 300 lions in the park. The dominant tree in this forest is the teak. The brief descriptions of the study area are given below in Fig.1.

Materials and Methodology

Two types of data were used to generate the vegetation cover map using remote sensing and GIS technique, i.e. Spatial and non-spatial. The spatial data contain IRS P6 LISS III satellite images with 23.5 meter pixel resolution in all 4 Bands, SRTM Digital Elevation Model, FSI forest map and Survey of India (SOI) topographic map on 1:250,000, 1:50,000 scale while Non-Spatial data covers Historical data of VCP, Socio economic data and Taxonomic data of the forest cover of Gir reserve forest. The forest phytomass was estimated as a product of phytomass C density by using the equation 1.

$$\text{Crown Density} = \frac{\text{Number of canopy hits}}{\text{Total number of steps}} * 100 \quad (1)$$

A brief description of adopted methodology is given in Fig. 2.

Generation of Vegetation cover: Regression tree method was developed using training data obtained from LISS-III images and Land sat-MSS data. It involved two steps: selection for most relevant variables and preliminary regression tree modeling. The best-selected predictor variables were then used for constructing model by analyzing the relationships within the data and created an appropriate regression tree and rule set. The rules created from the developed model in Cubist (Cubist Tutorial, 1997) were then interpolated spatially to the entire LISS-III data to produce a final vegetation cover map.

Unsupervised clustering, supervised maximum-likelihood classification and on-screen digitizing were performed to obtain vegetation and non-vegetation classes from the training data. The percent vegetation cover is then calculated as the percent of vegetation class for each 30 meter x 30 meter area corresponding to one LISS-III pixel. The percent vegetation cover data as a predicted variable

were then integrated to predictor variables data that were derived from LISS-III and both sets of data were used in the regression tree method. Table 1 shows predictor variables derived from LISS-III data. Vegetation cover created using regression tree method is illustrated in Fig.3.

Spatial Phytomass analysis: The total standing phytomass (including above ground) in GIR forests was estimated using information on field inventory based growing stock volume and the corresponding area under three different crown density classes grouped under four major forest categories by Forest Survey of India (FSI, 1995). The growing stock volume was converted to total biomass using biomass expansion factors as function of growing stock volume density (Brown *et al.*, 1999) and with additional biomass expansion factor for bamboo (Singh and Singh, 1999). The total phytomass pool in Gir forests was estimated at 6243740.7027 TgC. Table 2 represent the phytomass distribution for different density class, and their areal distribution shown in Fig. 4. The given equation 2 and 3 are responsible for phytomass estimation;

$$PD = GS \times DEN \times CC \times RC \times EF \quad (2)$$

$$\text{Phytomass C pool} = PD \times \text{total forest area} \quad (3)$$

Where,

PD: Forest Phytomass C density (t/km²)

GS: Growing stock 74.42 (m³/Hectare) - According to FSI

DEN: Density of wood 0.62(g/cm³)

CC: Carbon Content 0.5 (According to Brown *et al.*, 1999)

RC: Root correction factor (total dry matter /above ground dry matter) = 1.16 (Hall and Uhlig, 1991)

Ef: Expansion Factor = (1.9xD + 2.5x (O+M))/ D+O+M =2.431186

Fig. 1: Location map of study area

Fig. 2: Flow Chart of Methodology Adopted

Fig. 3: Vegetation cover map

Fig. 4: Forest Phytomass Map

Table 1: Distribution of Gir Reserve Forest on the Bases of Their Density

S. No.	Land use category	Area(in hectare)	Area (%)
1	Fairly Dense Mixed Jungle	61879.9	51
2	Fairly Dense Forest	19690.6	16
3	Dense mixed jungle	11006.7	9
4	Open Jungle	3392.18	3
5	Water (river + lake)	183130.2	16
6	Settlement	5525.8	3

Table 2: Distribution of Phytomass in Different Areas of Gir Reserve Forest

S. No.	Forest Type / Vegetation unit	Biomass (tonnes/ha) OR Expansion Factor	Area (ha)	Total biomass (tonnes)
1	Dense forest (C1)	65.059717	61879.9	4025888.782
2	Open Forest (C2)	65.059717	19690.6	1281064.863
3	Fairly Dense Forest (C3)	65.059717	11006.7	716092.78
4	Other vegetation	65.059717	3392.18	220694.27

Estimation of carbon Stock: Measuring Carbon stock particularly based on vegetation cover derived from remote sensing. This vegetation cover is then converted to carbon by multiplying with biomass-

carbon conservation factor. Table 3 shows conversion factor adopted in this study (CMFP, 2000). Based on these conversion factor an estimated of carbon stock (terrestrial carbon) of Gir was then created (Fig. 5).

Table 3: Conversion factor adopted in this study

S.No.	Conversion Factors
1	Total wood volume = vegetation cover x 1.454 x 0.396 (in m ³)
2	Total dry matter biomass = wood volume x 0.43 (in tonnes)
3	Total carbon = dry matter biomass x 0.5

Table 4: Distribution of Carbon in Different areas of Gir Reserve Forest

S. No.	Forest Type / Vegetation unit	Area (Hectare)	Total sequestered Carbon (tonnes)
1	C1	61879.9	1811649.952
2	C2	19690.6	576479.1884
3	C3	11006.7	322241.751
4	C4	3392.18	99312.4215

Fig. 5: Distribution of Sequestered Carbon

Results and Discussion

The present study attempts to estimate spatial distribution of biomass from satellite remote sensing data using statistical sampling method derived maps and spectral response modeling. The comparison between the two approaches suggests that both the approaches can be used depending on the system availability. While the first approach is based on visual interpreted maps, the second approach used digital image processing methods for modeling.

The total forest area has been calculated and classify on the bases of their vegetation density. On the basis of the forest density distribution map, field analysis and statistical operations the biomass has been calculated. Phytomass map (Fig. 4) was prepared by considering above parameter image interpretation of satellite image. The very dense forest area is having larger quantity of biomass (4025888 tonnes), open forest having (1281064 tonnes) fairly dense forest (716092 tonnes) and other vegetation having only (220694 tonnes). The total distribution of phytomass shown in Table 2. The total calculated phytomass is given as.

Analyzed Standing Total Phytomass=6243740.7027 TgC

By the help of Phytomass the sequestered carbon has been calculated. The estimated carbon pool was 1811649.9519 tonnes of very dense forest area, 576479.18835 tonnes of fairly dense forest, 322241.751 of open forest, other vegetation and other area having only 99312.4215 tonnes carbons. The distribution of carbon is shown in Fig. 5. And the distribution shown in Table4, the total carbon is given as,

Calculated Total sequestered Carbon =6243740.7027 T

Conclusion

The present study suggests approaches for using satellite remote sensing data for regional biomass mapping in Gir reserve forest (Gujarat). The stratified random sampling in the homogeneous vegetation strata mapped using satellite remote sensing has been effectively utilized to extrapolate the sample point biomass observations in the first approach. The approach of incorporating SEBAL (Surface Energy Balance Algorithm for Land Tree Resources Outside Forests) may prove to be a powerful but relatively cheaper method for use under the Kyoto Protocol as carbon management (sequestration and monitoring) becomes an international trade through the implementation of the Clean Development Mechanisms (CDMs), new afforestation projects. This approach, involving the aspects of GIS and remote sensing, has the capability

of being used as a regional, national or global scale carbon sequestration measuring and monitoring tool.

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